

sions for accepting removable storage media. In the preferred embodiment, the digital video tapes recorded by the system of FIG. 2 are installed in a tape-storage "jukebox" 208 for easy access during editing. Such tape cassette handling devices are well-known in the art of computer data storage, and are generally utilized for data back-up applications or for archival storage.

The edits incorporated into the edit decision list are utilized to sequence the various digital tapes so as to assemble a recording of the desired program materials into a final finished product, which is then recorded on the videotape recorder 202. This video recorder may be implemented as any of the commonly used choices for analog recorders, including, among others, 1" C-format, Betacam, Betacam-SP, U-matic-SP, and Hi-8. If implemented as a digital recorder, the available choices include, among others, D-1, D-2, D-3, D-5, DCT, and Digital Betacam. Furthermore, the final format could be another digital data tape such as the type used for program source material or any other removable storage media. Since the time-code identification numbers on the removable media of the off-line system correlate with those utilized in the on-line system, no conversion or adaptation of the edit decision list is needed. The video monitor 204 is used to manipulate the window-based edit system control software, and to view the program materials as the edit process proceeds. This process will be essentially automatic, as all of the necessary decisions already have been made in the off-line editing process as described above. In addition, this is an appropriate time for adding digital video effects to the program or to implement any special effects included in the program script.

The invention may be used for other applications limited to record/playback, without implementing the full range of editing features. For example, in applications such as master playback for video duplication, the program master tape must be played, rewound to the beginning, and then restarted, on a repeating cycle. In facilities employing a conventional video tape recorder, this represents a great deal of physical stress on the program master tape, thereby requiring a large number of copies of this master tape when many production runs are required to complete an order. In addition, some production time is lost due to the rewinding process itself. In a disk-based application of the system disclosed herein, there is no significant deterioration of the master program even in repeated usage, and it is possible to begin playing a program at any point desired, with essentially no delay due to cueing the program media to the physical location containing that part of the recorded program. In order to provide the necessary recording time duration, additional hard-disk drives would be added to achieve the required playback duration. Based on an MPEG-2 data-compression ratio of 20:1 (with a 4:2:2 recording system for NTSC signals), two hours of digital video would require approximately 8 GB of disk storage capacity. Disk-drives offering capacity of 9 GB are currently available, and until removable media achieve comparable levels, a program would accordingly be loaded into internal or external disk-storage units from the required number of removable media units.

The invention may also be employed as a playback unit for cable television usage or other extended-playing time applications. By adding as many "juke-box" units as desired, it is a simple matter to extend the playback time capability of the system, with each "juke-box" providing approximately 40 hours of digital video playback. By fully utilizing the RAM-based audio/video buffering capabilities discussed with reference to FIG. 2, it is possible to supply digital video

playback on a continuous basis by changing the tape storage cassettes or cartridges "on-the-fly" while video playback proceeds. If provided with computer-readable identification codes on each cassette or cartridge, the computer is able to locate the "juke-box" and the particular physical storage slot containing program materials that previously have been scheduled for playback. Identification and library management systems of this type are well-known in the art, and are in common usage implemented as "cart-machines" employed for playback of commercial advertisements or other program materials at broadcast stations. In addition, playback at any frame rate or television system standard would be available, in accordance with our co-pending U.S. application Ser. No. 08/298,104 filed Aug. 30, 1994.

The versatility of the Digital Video Production System may be enhanced further, if planning for the program is begun by providing script and staging information to the computer in advance of editing, or even in advance of filming or taping the original production. Computer software having access to the script materials will enable the operator to match the scenes to the recorded video materials quickly, thereby speeding the editing process. In addition, it is common practice in broadcast-television news studios to use remotely-controlled cameras to telecast the live programs. By coupling the software script materials to instructions for control of the camera movements, the capabilities of all of these systems will be optimized.

Having thus described the system, we claim:

1. A digital audio/video production system adapted for use with an on-line video editing facility, the production system comprising:
 - a digital video recorder capable of simultaneously recording information representative of the same program source material, including correlated edit-time-code information, onto first and second removable storage media in first and second formats, respectively, the information in the first format being data-compressed relative to the information in the second format;
 - a programmed personal computer configured to receive the first removable storage medium, enabling an operator to edit the information representative of the program source material in the first format in off-line fashion so as to develop an edit decision list; and
 - means to transfer the edit decision list to an on-line video editing facility, the on-line editing facility being further configured to receive the second removable storage medium, whereby an operator of the on-line facility may edit the program source material in the second format using the edit decision list to create a final video production.
2. The digital video production system of claim 1, wherein the information in the second format is non-compressed.
3. The digital video production system of claim 1, wherein the digital video recorder forms part of a camcorder.
4. The digital video production system of claim 1, wherein the first removable medium is a magnetic hard disk.
5. The digital video production system of claim 1, wherein the first removable medium is an optical disk.
6. The digital video production system of claim 1, wherein the first removable medium is a magneto-optical disk.
7. The digital video production system of claim 1, wherein the second removable medium is a tape drive.
8. The digital video production system of claim 1, including digital audio and video program data which are interleaved.
9. The digital video production system of claim 1, the means to transfer the edit decision list to the on-line video

editing facility including means to record the edit decision list onto a third removable storage medium.

10. The method of producing a final video program, comprising the steps of:

providing video program source material in first and second digital formats, the material in the first format being compressed relative to the material in the second format;

recording the material in the first and second formats, respectively, onto first and second removable storage media along with correlated edit-time-code information;

interfacing the first storage medium to an off-line video editing system to develop edit decision information;

transferring the edit decision list to an on-line video editing system;

accessing the program material in the second storage medium using the on-line video editing system; and

editing the material in the second format on the second storage medium in accordance with the edit decision list to produce a final video program.

11. The method of claim 10, the second format being a non-compressed format.

12. A digital video production system adapted to deliver program material and an accompanying edit decision list to an on-line video editing facility for the purpose of creating a final program, the system comprising:

digital video recording apparatus, including:

an input to receive a video program,

means to digitally compress the program in accordance with more than one compression ratio,

an interface to a first removable storage medium, and an interface to a second removable storage medium,

means to simultaneously record the video program onto the first removable storage medium at a first compression ratio and onto the second removable storage medium at a second compression ratio, the first compression ratio being greater than the second; and

an off-line digital video editing system, including: an interface to receive the first removable storage medium.

a display to review portions of the video program, enabling a user to make edit decisions concerning the program, and

an interface to a third removable storage medium to store a list of the edit decisions,

whereby an on-line video editing facility, upon receiving the second and third storage medium, may be used to produce a final, edited version of the program in accordance with the decision list.

13. The digital video production system of claim 12, wherein the second compression ratio is zero.

14. The digital video production system of claim 12, wherein the off-line digital video editing system forms part of a programmed personal computer.

15. The digital video production system of claim 12, wherein the digital video recorder forms part of a camcorder.

16. The digital video production system of claim 12, wherein the first removable medium is a magnetic disk drive.

17. The digital video production system of claim 12, wherein the first removable medium is an optical disk.

18. The digital video production system of claim 12, wherein the first removable medium is a magneto-optical disk.

19. The digital video production system of claim 12, wherein the second removable medium is a tape drive.

20. The digital video production system of claim 12, including interleaved digital audio and video program data are interleaved.

21. The digital video production system of claim 12, wherein the program includes separately recorded audio and video portions.

22. A digital video recording apparatus adapted or use with an on-line video editing facility and a personal computer configured to perform off-line editing, including edit-list development, the apparatus comprising:

a camera outputting information representative of a video program;

means to digitally compress the program information at a plurality of compression ratios;

a removable disk drive to store a highly compressed version of the program information suitable for off-line editing using the personal computer; and

a removable tape drive to store a less compressed version of the program information suitable for on-line editing; both versions of the program being stored with correlated edit-time-code information, thereby enabling the on-line editing to use the edit list developed during off-line editing.

23. The digital video recording apparatus of claim 22, wherein the camera, means to digitally compress the program at a plurality of compression ratios, removable disk drive, and removable tape drive are all integral to a camcorder.

24. A digital audio/video production system, comprising:

(a) digital video recording apparatus, including:

an input to receive a video program,

first and second removable digital storage media, and means to simultaneously record the program, including correlated edit-time-code information, onto the first and second removable storage media in first and second formats, respectively, the first format being data-compressed relative to the information in the second format;

(b) a first video editing system, including:

means to receive the first removable storage medium, and controls enabling an operator to edit the program in the first format and develop a set of edit decision directives; and

(c) a second video editing system, including:

means to receive the second removable storage medium, means to receive the edit decision directives, and means to edit the program information in the second format in accordance with the edit decision directives to create a final video production.

25. The digital audio/video production system of claim 24, wherein the digital video recording apparatus includes means to receive a plurality of the first removable storage media.

26. The digital audio/video production system of claim 24, wherein the second video editing system includes means to receive a plurality of the second removable storage media, wherein the edit decision directive being applicable to all of the second removable storage media received.

27. The digital audio/video production system of claim 26, wherein the digital video recording apparatus forms part of a camcorder.

28. The digital audio/video production system of claim 26, wherein the first video editing system forms part of a programmed personal computer.

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29. The digital audio/video production system of claim 26, wherein the first removable digital storage medium is a magnetic disk.

30. The digital audio/video production system of claim 26, wherein the first removable digital storage medium is an optical disk.

31. The digital audio/video production system of claim 26, wherein the first removable digital storage medium is a magneto-optical disk.

32. The digital audio/video production system of claim 26, wherein the first removable digital storage medium is a semiconductor memory.

33. The digital audio/video production system of claim 24, wherein the second removable digital storage medium is a magnetic tape.

34. A video production method, comprising the steps of: simultaneously recording information representative of a video program, plus correlated edit-time-code information, onto first and second removable digital storage media in first and second formats, respectively, the program information in the first format being data-compressed relative to the program information in the second format;

receiving the first removable storage medium at a first video editing facility and editing the program information at the first facility in the first format to develop a set of edit decision directives based upon the edit-mime-code information; and

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receiving the second removable storage medium and edit decision directives at a second video editing facility and editing the program information at the second facility in the second format in accordance with the edit decision directives so as to create a final video production.

35. The video production method of claim 34, further including the step of recording the final video production onto a third removable storage medium at the second video editing facility.

36. The video production method of claim 34, further including the step of outputting the final video production as the program information is edited in the second format in accordance with the edit decision directives.

37. The video production method of claim 34, wherein the step of editing the program information at the second facility further includes the step of adding audio special effects in the final video production.

38. The video production method of claim 34, wherein the step of editing the program information at the second facility further includes the step of adding video special effects in the final video production.

39. The video production method of claim 38, wherein the step of adding video special effects includes the step of adding titling.

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